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RESEARCH ARTICLE

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Procambrus clarkii (Crustacea: Cambaridae) a biological control agent against four intermediate host snails in Egypt

ABSTRACT:

Heterophyasis is a chronic parasitic disease infecting fish eaten by man. One of strategies to eradicate parasitic diseases is the bio-control of its vector snails. Lab experiments and field survey have been carried out to investigate the impact and the relationship between the exotic crayfish; *Procambarus clarkii*, two freshwater snails (*Pirenella conica* and *Cleopatra bulimoides*) and other two land snails (*Monacha cartusiana* and *Eobania vermiculata*) in Egypt. In the Lab, these snails and clover *Lactuca sativa* species were reported to serve as food for freshwater crayfish. The results of the experimental Lab indicated that the vector snails; *Pirenella conica* and *Eobania vermiculata* were the type of food of first choice for the crayfish after clover followed by *Cleopatra bulimoides* but *P. clarkii* show no preference against *Monacha cartusiana* as type of food. So, the present investigation indicated that *P. clarkii* can effectively control or eliminate certain freshwater snail species, including those involved in the transmission of human Heterophyasis. Therefore, *P. clarkii* appeared to act as a biological control agent of snail-transmitted diseases in selected habitats in Egypt.

KEY WORDS:

Procambarus clarkii; *Pirenella conica*; *Cleopatra bulimoides*; *Monacha cartusiana*; *Eobania vermiculata*

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INTRODUCTION:

The red swamp crayfish, *Procambarus clarkii*, introduced into Egypt, Giza (Manial-Sheiha) at 1980, it has become well established and now supported a small but thriving aquaculture industry (Fishar, 2006). This crayfish has since dispersed over a wide area in Egypt, giving rise to concerns about its ability to disrupt natural ecosystems elsewhere. In addition, *P. clarkii* may adversely affect fin fisheries and has been implicated as a pest in rice cultivation schemes outside of Africa. In addition to its possible impact on species of direct relevance to human commerce and health, the effect of *P. clarkii* on other non-target organisms and on natural ecosystems in general should be considered as well. Crayfish are voracious omnivores and are often able to significantly alter the structure of natural aquatic communities (Lodge and Lorman, 1986; El-Dien *et al*., 2013 a&b). This might be achieved by direct depredation of indigenous aquatic invertebrates or vertebrates, or by vigorous consumption of macrophytes and detritus used by other organisms as food sources or as cover from predators, *P. clarkii* may also serve as a competitor of snails of medical and veterinary significance. On the other hand, a field survey for the exotic freshwater crayfish was carried out along the River Nile, introduced accidentally to Egypt during early 1980's, by Ibrahim *et al*. (1995 &1996). They found that the crayfish has established viable populations in the aquatic ecosystems of Giza, Cairo and some Nile Delta Governorates. The coefficients of conditional values have indicated suitability of the new environment for this crayfish with regard to feeding condition. They also studied the feeding behaviour of the exotic crayfish and its prospect in the bio-control of local vector snails and they found that smaller snails represent an easier prey to be attacked by the crayfish. Huner and Barr (1991) and McClain *et al*. (1993) studied the selectivity of this species for combating certain freshwater snails, which are vectors of parasitic diseases. Moreover, *P. clarkii* has been also known for its outstanding feeding capacity on some aquatic pest weeds (Groves, 1985; El-Dien *et al*., 2013 a&b).

Therefore, the present study aimed to measure the feeding activity of *P. clarkii* against four intermediate host snails *Pirenella conica* and *Cleopatra bulimoides* and other two land snails including *Monacha cartusiana* and *Eobania vermiculata* which are consumed as the major transmitting agent of parasitic diseases, these will be done to consider if *P. clarkii* represents a biological control agent for parasitic diseases in Egypt.

MATERIAL AND METHODS:

Laboratory experiments:

Fifty of adult red swamp crayfish *Procambarus clarkii* (Crustacea: Cambaridae) of different sizes (3.5 – 6.5 cm in length) were collected from different localities along the River Nile at Giza Governorate, Egypt. They were transported alive to the Laboratory of Invertebrates, Zoology Department, Cairo University and maintained in glass aquaria (50 x 30 x 20 cm) filled with continuously aerated dechlorinated tap water which was changed daily. The experiment of the present study designed in the form of, six aquaria filled with 1/6 of their volume with water and ten specimens of adult *P. clarkii*, as:

1- **First aquarium:** contained clover *Lactuca sativa* species, two species of freshwater snails, *Pirenella conica* and *Cleopatra bulimoides,* and other two species of land snails, including *Monacha cartusiana* and *Eobania vermiculata*.

2- **Second aquarium:** contained two species of freshwater snails, *P. conica* and *C. bulimoides*, and other two species of land snails, including *M. cartusiana* and *E. vermiculata*.

3- **Third aquarium:** contained *L. sativa* species and two species of freshwater snails, *P. conica* and *C. bulimoides*.

4- **Fourth aquarium:** contained two species of freshwater snails, *P. conica* and *C. bulimoides.*

5- **Fifth aquarium:** contains *L. sativa* species and two species of land snails, including *M. cartusiana* and *E. vermiculata.*

6- **Sixth aquarium:** contains two species of land snails, including *M. cartusiana* and *E. vermiculata.*

The feeding activity (number of snails eaten per day) and the response of *P. clarkii* were observed and calculated in the six aquaria prepared for about two weeks. The capability of the crayfish used to be a biological control toward the four snails was documented.

Statistical Analysis:

The obtained results were subjected to analysis of variance (ANOVA) using SPSS Program Ver. 15.

RESULTS AND DISCUSSION:

Mollusca represented as the second largest phylum of the animal kingdom, forming a major part of the world fauna (Lush, 2007). The Gastropod is the only class of molluscs to have successfully invaded land (Smith and Kershaw, 1979). They are one of the most diverse groups of animals, both in shape and habit (Mejía and Zúňiga, 2007). Estimates of total extant species ranged from 40,000 to 100,000 but may be as high as 150,000 (Ponder and Lindberg, 1997), with about 13,000 named genera for fossil and recent species (Bieler, 1992). Among gastropods, land snails belonged to subclass *Pulmonata* were one of the most numerous with almost 35,000 described species of the world (Solem, 1984), mostly found in the tropics, where the majority remain undiscovered and undescribed, partly because of under-exploration, and partly because of their often-minute sizes (Stanisic, 1990; DeWinter, 1992 & 1995; Tattersfield, 1994; Cowie *et al*., 1995; Emberton, 1995 a, b, & 1996). Many terrestrial molluscs have become successful world travellers (Robinson, 1999). Most of these traveling species have had no impact on humans, but several species have become significant as agricultural pests and as vectors of parasites (Lush, 2007).

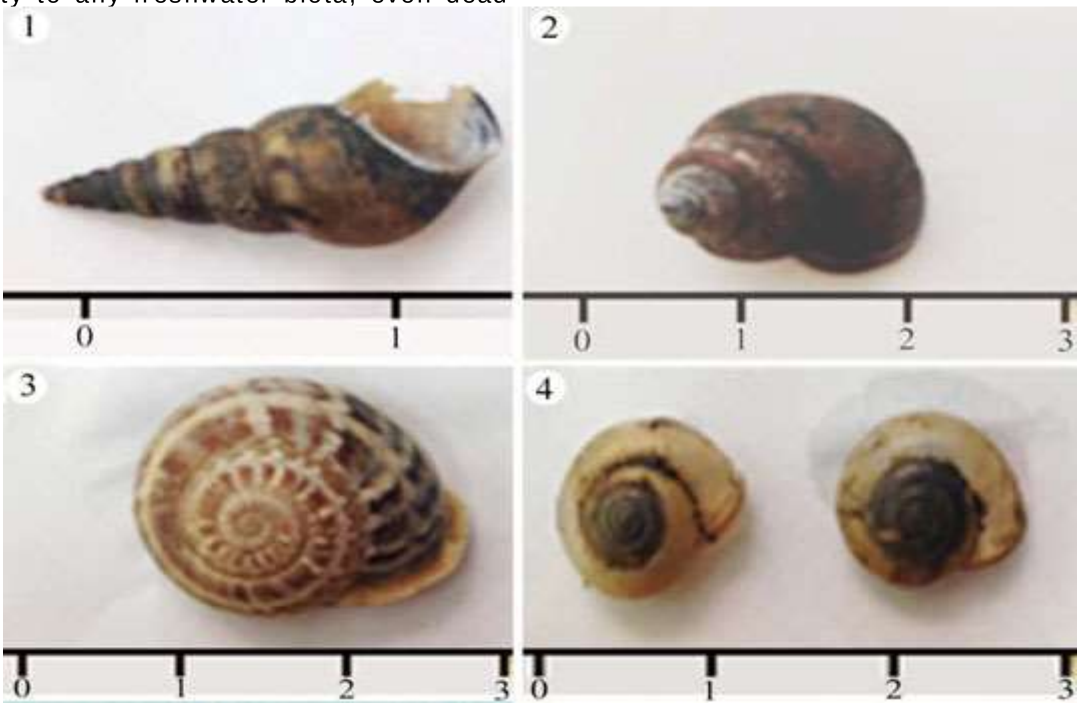
Freshwater molluscs have been known to play significant roles in the public and veterinary health and thus need to be scientifically exploring more extensively (Supian and Ikhwanuddin, 2002). About 100 species of freshwater gastropods reported to act as intermediate hosts for the diagnostic trematode parasites and among Prosobranchs, members of the family *Pilidae* and *Thiaridae* were recorded to harbour larval trematodes (Subba-Rao, 1993).

Land Mollusca pests are serious problem, every year; damage involving considerable financial losses inflicted on cereal, potatoes, vegetables, lettuce, carrots, cabbage, maize, clover as well as other agricultural and horticultural crops. They eat leaves, roots and tuber of nearly all vegetables, fields crops, ornamental plants as well as fruits in field, garden and greenhouse. Land snails cause heavy damage, especially to seeds and seedlings of cereals and seeds of oil plants. Snails cause serious economic damages to the leaves and fruits, which were observed on trunk crops and ornamental plants, as well as apple, citrus, peach, palm and vegetables. Several studies were carried out on land snails of Egypt included those of El-Okda (1980 &

1984), El-Okda *et al*. (1989), El-Deeb *et al*. (1996 & 2003), Lokma (2007), Shahawy *et al*. (2008), Shoieb (2008), and Rady *et al*. (2014).

Food-borne parasitic infections have recently been identified as an important public health problem with considerable economic impact in terms of morbidity, loss of productivity and healthcare costs. Poor sanitation and traditional methods of food preparation have accelerated the spread of food-borne trematode infection (Phan *et al*., 2010). Fish are a good source of quality protein, but various diseases including parasitic infections pose a threat to fish cultivation, which is a valuable source of food and employment in developing countries (Yooyen *et al*., 2006). In addition to the economic loss to farmers, many of the parasites, particularly trematodes, were also of zoonotic importance. Eating raw or improperly cooked or processed fish is the main source of these infections for humans, and this has been reported from various geographical regions (Park *et al*., 2009). The World Health Organization (WHO) has estimated that the number of people currently infected with fish-borne trematodes exceeds 18 million, and many more are at risk (WHO, 1995).

The data obtained from laboratory indicated that *P. clarkii* is a polytrophic animal that can serve as an effective agent for controlling heterophyasis, prohemistomiasis and other snail borne parasitic diseases. It has a large feeding capacity to any freshwater biota, even dead organisms. The results shown in table 1 indicated that the crayfish during the present study, *P. clarkii* consumed all species of plants *Lactuca sativa* that were added in their aquaria and can be considered an essential part of its diet (Groves, 1985; Bishop, 1992). On the other hand, came next to the former in food preference of the crayfish it consumes large numbers of snail species, Regarding the snails, the crayfish tends to be selective according to shell hardness and the size of the snail. Therefore, the freshwater snail *Pirenella conica* and the land snail *Monacha, cartusiana* were preferred preys to be attacked by *P. clarkii* (Figs 1-4). This was primarily because the shell was thin and easy to break, before getting to the soft parts. They usually crushed the shell between their large claws and eat the soft body of the snail; though the crayfish has been observed to devour the whole animal with its shell (Figs 5 & 6). It was also noticed from the present study that the crayfish could devour ten large-sized snails from each of the snail species (Table 1) during the first three days only. The operculated snails *Cleopatra bulimoides,* but after fullness the crayfish never attacks the latter snail group, *Eobania vermiculata* was more resistant to the crayfish attack due to its shell hardness and the bigger size. Finally, in the second week where there is no anymore snail except *Eobania vermiculata,* the crayfish showed cannibalism phenomenon (Fig. 7), it is very common among crayfish individuals (Groves, 1985).



Figs 1-4. Different snail species used in this experiment. 1 *Pirenella conica*. 2 *Cleopatra bulimoides*. 3 *Monacha cartusiana*. 4 *Eobania vermiculata*.

Figs 5 & 6. Shells after devouring by the crayfish.

Table 1. the quantity of food consumption of *Procambarus clarkii* against two freshwater snail species *Pirenella conica* and *Cleopatra bulimoides* and other two land snails including *Monacha cartusiana* and *Eobania vermiculata* and *Lactuca sativa* in the laboratory.

Parameters / No of aquaria	Food types	No. of snails	Food consumption/day							Quantity of food consumption during	
			1	2	3	4	5	6	7	One week	Two weeks
Aquarium 2 (contains *Lactuca sativa*)	*Pirenella conica*	10	-	7	3	-	-	-	-	Consumed through two days	Consumed through the first week
	Cleopatra bulimoides	10	-	-	3	3	4	-	-	Consumed through three days	
	Monacha cartusiana	10	-	-	6	3	1	-	-	Consumed through three days	
	Eobania vermiculata	10	-	-	-	-	-	-	-	Not preferred as food type	
Aquarium 2	*Pirenella conica*	10	8	2	-	-	-	-	-	Consumed through two days	Consumed through the first week
	Cleopatra bulimoides	10	-	4	3	3	-	-	-	Consumed through three days	
	Monacha cartusiana	10	-	7	3	-	-	-	-	Consumed through two days	
	Eobania vermiculata	10	-	-	-	-	-	-	-	Not preferred as food type	
Aquarium 3 (contains *Lactuca sativa*)	*Pirenella conica*	10	-	5	5	-	-	-	-	Consumed through two days	Consumed through the first week
	Cleopatra bulimoides	10	-	-	2	3	5	-	-	Consumed through three days	
Aquarium 4	*Pirenella conica*	10	6	4	-	-	-	-	-	Consumed through two days	Consumed through the first week
	Cleopatra bulimoides	10	-	1	4	5	-	-	-	Consumed through three days	
Aquarium 5 (contains *Lactuca sativa*)	*Monacha cartusiana*	10	-	4	4	2	-	-	-	Consumed through three days	Consumed through the first week
	Eobania vermiculata	10	-	-	-	-	-	-	-	Not preferred as food type	
Aquarium 6	*Monacha cartusiana*	10	5	3	2	-	-	-	-	Consumed through three days	Consumed through the first week
	Eobania vermiculata	10	-	-	-	-	-	-	-	Not preferred as food type	

*All aquaria contain ten specimens of *P. clarkia;* * $p > 0.05$

Fig. 7 Cannibalism phenomenon in the crayfish.

These research results have led us to believe that *P. clarkii* is effective in controlling and/or eliminating certain snails of relevance to human public health. Snail-transmitted trematode parasites such as *Schistosoma* and *Fasciola* assume considerable medical and veterinary significance in tropical Africa. We have observed a strong negative association between the presence of medically important pulmonate snails and the crayfish *P. clarkii* in freshwater habitats in Kenya (Hofkin *et al*., 1991; El-Dien *et al*., 2013 a, b, &c) and in Egypt (Khalil and Sleem, 2011). As such, this crayfish may represent a viable option as a biological control agent of *Heterophyes,* and other snail-borne diseases. Some of the potential advantages offered by *P. clarkii* as a control agent are: 1) its impact on target species is likely to be long-lasting and, unlike chemically based methods of control, would not have to be repeatedly applied; 2) the expense involved in its use would be minimal, 3) it could simultaneously reduce transmission of all snail-transmitted parasites, including species relevant to both humans and domestic animals, and 4) because *P. clarkii* is able to withstand habitat drying, it could be used in both permanent and seasonal transmission sites. Enthusiasm for the use of *P. clarkii* in snail control operations must, however, be tempered by the realization that biological control, in and of itself, is probably only rarely sufficient for bringing about a complete cessation of transmission. Moreover, the use of *P. clarkii* in particular poses certain environmental risks that must be carefully considered before their widespread use as putative control agents can be advocated. Species such as *P. clarkii* offers the potential of increased economic opportunity and improved public health. Furthermore*, P. clarkii* is, for better or worse, already firmly established in Egypt and may well increase its present range, irrespective of human activity. Bearing this in mind, further studies should focus on how to best manage this resource, and how to take maximum advantage of its positive attributes while keeping its environmental effects to a minimum.

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COMPLIANCE WITH ETHICAL STANDARDS

All procedures contributing to this work comply with the ethical standards of the relevant national guides on the care and use of laboratory animals and have been approved and authorized by Institutional Animal Care and Use Committee (IACUC) in Faculty of Science, Cairo University, Egypt.

CONFLICT OF INTEREST

The authors have indicated that they have no conflict of interest regarding the content of this article.

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بروكامباروس كلاركي (قشريات: كمبريدي) كعامل تحكم بيولوجي ضد أربعة أنواع من القواقع كعوائل وسيطة في مصر

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هيتيروفياسيس هو مرض طفيلي مزمن يصيب الأسماك التي تؤكل من قبل الإنسان. لذلك، واحدة من الاستراتيجيات المتاحة للقضاء على الأمراض الطفيلية هو السيطرة البيولوجية على القواقع الناقلة لها. وقد أجريت تجارب ومسح ميداني لبحث تاثير وعلاقة جراد البحر *بروكامباروس كلاركي* باثنين من قواقع المياه العذبة (*بيرينيلا كونيكا* و*كليوباترا بوليمويدس*) واثنين آخرين من القواقع البرية (*موناشا كارتوسيانا* و*إوبانيا فيرميكولاتا*) في مصر. كما تم استخدام الخس *(لاكتوكا ساتيفا)*كغذاء لجراد البحر. وأشارت نتائج البحث إلى أن *بيرينيلا كونيكا* و*إوبانيا فيرميكولاتا* هما الخيار الأول كغذاء لجراد البحر بعد الخس تليها *بوليمويدس كليوباترا* ولكن *بروكامباروس كلاركي* لم يظهر قابليته نحو *مونتشا كارتوسيانا* كغذاء. لذلك اوضحت نتائج البحث إلى أنه يمكن استخدام *بروكامباروس كلاركي* للسيطرة والقضاء على بعض أنواع قواقع المياه العذبة، بما في ذلك النوع الذي يشارك في انتقال هيتيروفياسيس للإنسان. لذا يمكن اعتبار *بروكامباروس كلاركي* كعامل تحكم بيولوجي للأمراض التي تنتقل عن طريق القواقع في مصر.